B.C. Hydro

Columbia River Keenleyside Powerplant Project

Preliminary summary
of principal impacts
and mitigation opportunities

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COLUMBIA RIVER
KEENLEYSIDE POWERPLANT PROJECT
PRELIMINARY SUMMARY OF PRINCIPAL IMPACTS AND MITIGATION OPPORTUNITIES

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PREFACE

This Preliminary Summary Report has three parts: Part I contains an overview of the project based on the current Engineering Description. Details of the project as currently proposed are provided; however, it should be noted that as the design advances further changes could result.

Part II contains a summary of environmental and socio-economic impacts, and mitigation opportunities proposed by the consultants. The impacts and mitigation opportunities were established for a reservoir operated in accordance with Regime 1, the current drawdown conditions. Reports have been revised to consider both Regime 1 and Regime 2, a reduced drawdown condition. However, the study conclusions and recommendations are not expected to change significantly as Regime 1 in general produces the more severe impacts.

A series of public consultation meetings based on this report are planned to begin in fall 1983. The results of these meetings as well as previous meetings will make up a portion of the application to the Ministry of Energy, Mines and Petroleum Resources for an Energy Project Certificate for the Keenleyside-Murphy Project in accordance with the B.C. Utilities Commission Act.

The detailed environmental impact reports from which this summary report is drawn will be available publicly after these impact reports are finalized.

Similar summary reports will be issued for the Murphy Creek Project and the Keenleyside-Murphy Transmission Project.

PART I - THE PROJECT
SECTION 1.0 - INTRODUCTION

1.1 BACKGROUND

Under the terms of the Columbia River Treaty, the Hugh Keenleyside Dam was constructed to provide storage for downstream flood control and to increase power generation in the United States. The dam, an earthfill and concrete structure on the Columbia River 7 km upstream of Castlegar (see Fig. 1-1), was completed in late 1968. The dam controls runoff from a 36 500 km^2 drainage area and impounds a reservoir (Arrow Lakes Reservoir) of 8.8 x $10^9 m^3$ extending 233 km north to Revelstoke.

Provisions for generating facilities at Keenleyside Dam were investigated during the design of the dam, but it was decided not to include them in the initial construction. Feasibility studies of the downstream Murphy Creek Project have been completed and because of the considerable interdependence of Keenleyside and Murphy, a prefeasibility level study for Keenleyside was undertaken to permit a combined optimization of both projects. Keenleyside was studied in combination with several alternative reservoir levels for the Murphy Creek Project. In addition to a "no Murphy" case, alternative Murphy reservoir levels of El. 424, El. 427 and El. 430 were investigated. These levels are respectively 4, 7 and 10 m above the existing tailwater level at Keenleyside under average flow conditions and, therefore, would significantly affect the potential generating capability at Keenleyside. Similarly, the Murphy Project would affect generation at Cominco's Brilliant plant. Based on subsequent optimization studies, a Murphy Creek Project with a reservoir level of El. 424 along with development of the Keenleyside Powerplant was selected as the basis for further studies.

1.2 ONGOING STUDIES

In July 1981, when the Prefeasibility Study for Keenleyside was completed, studies for the Murphy Creek Project were already well into the Preliminary Design phase. Because of the interdependence of the two projects it was decided to omit the feasibility level study for Keenleyside and commence Preliminary Design studies in September 1981. Phase 1 of these studies has included field investigations and office studies sufficient to permit all major decisions to be reached on the following project features:

1. arrangement of structures,

2. type and number of units,

3. optimum turbine and generator capacity.

During the subsequent Phase 2 Preliminary Design Study, all of the major project components will be optimized.

SECTION 2.0 - GEOGRAPHIC SETTING

2.1 COLUMBIA RIVER DEVELOPMENT

The Columbia River flows a distance of 760 km from its source in Columbia Lake to the Canada - U.S.A. border near Trail; in this course, it falls about 410 m from El. 810 to El. 400.

Mica Dam became operational in 1973 and provides $14.8 \times 10^9 m^3$ of live storage, of which $8.6 \times 10^9 m^3$ are committed to operation under the Columbia River Treaty. Power facilities at Mica develop a head of about 170 m and have an ultimate rated capacity of 2610 MW. The regulated discharge from Mica has made possible a run-of-the-river plant at Revelstoke with a comparable power output. Construction of the 2700 MW Revelstoke Project began in 1976. The Arrow Lakes Reservoir, formed by the Hugh Keenleyside Dam, became operational in 1968.

2.2 AREA DESCRIPTION AND PROJECT LOCATION

From the Mica Project to the lower portion of the Arrow Lakes Reservoir, the Columbia River flows from north to south in a well defined, generally steep-sided, narrow valley. The valley sides are heavily forested. Adjacent to the valley the higher peaks rise to about El. 3050. Near the lower end of the reservoir the Columbia River changes its course eastward for about 16 km to Castlegar where it again turns southward and is joined by the Kootenay River. The Hugh Keenleyside damsite is located within the east-west reach, some 7 km upstream of Castlegar (see Fig. 1-1).

From Castlegar the damsite can be reached by paved highways on either side of the Columbia River. The Canadian Pacific Railway also passes the damsite on the south side of the river.

SECTION 3.0 - GENERAL DESCRIPTION

3.1 EXISTING FACILITIES

The Hugh Keenleyside damsite is situated at a point where bedrock occurs at a fairly shallow depth on the left (north) abutment but dips steeply southward under the original riverbed. The dam, therefore, comprises a 360 m length of concrete structures founded on bedrock on the left abutment and a 450 m long earthfill dam founded on silts, sands and gravels in the riverbed and on the right abutment. To control seepage under the earthfill dam, an impervious till blanket was constructed extending some 680 m upstream of the dam.

The concrete structures comprise, from the left abutment, the 100 m long north bulkhead; low level ports Nos. 1 to 4 (four 6.1 m wide x 7.3 m high gated outlets at sill El. 411.5 m); the sluiceway containing four 15.2 m wide x 16.8 m high vertical lift gates at a crest level of El. 424.9 m; low level ports Nos. 5 to 8 (similar to Nos. 1 to 4); the navigation lock (15.2 m wide and 88 m between gates); and the south bulkhead section connecting with the earthfill dam.

The earthfill dam is comprised mainly of sand and gravel fill with an upstream impervious till core connecting with the blanket. The maximum height of the dam, above the original riverbed, is approximately 52 m.

The crest level of the concrete structures is El. 443.8 m rising to El. 444.7 at the left abutment and at the earthfill dam.

The normal maximum reservoir level is El. 440.1 m. However, the dam was designed for temporary surcharge to El. 441.7 m. To improve flow regulation for downstream U.S. powerplants, and with the permission of the Comptroller of Water Rights, the reservoir has been temporarily

surcharged to El. 440.7 m in seven of the last 12 years. Between El. 440.1 m and the normal minimum reservoir level of El 419.6 m, the reservoir contains a useable storage of $8.8 \times 10^9 m^3$. The 0.6 m surcharge contains an additional $0.3 \times 10^9 m^3$.

3.2 PROPOSED GENERATING FACILITIES

The proposed generating facilities would be located on the left (north) bank, between the existing discharge facilities and the Robson-Broadwater Highway, as bedrock suitable for the powerplant foundation is present only on the north abutment.

During the prefeasibility studies three basic arrangements were considered. One would involve a 900 m long canal skirting the impervious blanket as suggested during earlier studies in 1962. The second arrangement would utilize four of the eight low level ports as intakes for two generating units. The third and proposed alternative would comprise a powerhouse adjacent to the end of the existing north bulkhead section with a short intake approach channel connected to the reservoir immediately upstream of the dam.

3.3 FEATURES OF GENERATING FACILITIES

(a) Approach Channel

The approach channel leading from the reservoir to the powerplant would have an average length of about 150 m and a maximum top width of about 230 m near the channel entrance. The invert level at the entrance has been kept at a fairly high level, El. 423, to minimize the amount of earthwork following cofferdam removal. Such a level is practical because, due to turbine head limitations, the powerplant would not operate at reservoir levels lower than

El. 430. From the entrance at El. 423 to the debris trap at El. 407.5 in front of the powerplant intake, the channel invert would slope downward at a slope ranging from about 4H:1V to 10H:1V.

(b) Powerplant

(i) Powerplant Capacity

The total installed capacity of 210 MW was selected following an economic study in which the turbine and generator capacities were optimized to produce the highest net annual benefits. On the basis of this optimization study and considering the limits of current experience with large size Kaplan turbines at heads similar to that at Keenleyside, three vertical shaft Kaplan turbines were selected.

(ii) Powerhouse

The powerhouse would contain three 70 MW vertical shaft Kaplan turbines and generators, with a service bay at the north end. The powerhouse would be located between the end of the existing north bulkhead and the Robson-Broadwater Highway.

The indoor powerhouse would have a machine hall 23.5 m wide x 90 m long, plus a 24.5 m long service bay. A single 500-t overhead bridge crane would be provided.

(iii) Intakes

The intakes would be integral with the powerhouse and, for each unit, would comprise three openings separated by piers with trashracks at the upstream face, guides for service bulkheads or stoplogs a short distance downstream, and hydraulically controlled operating gates.

(iv) Turbines

The three turbines would be vertical shaft Kaplan units operating at 66.67 rpm and developing their rated output of 71 100 kW at a net head of 16.0 m. The rated discharge of each unit would be approximately 500 m^3/s. The combined three-unit discharge of 1500 m^3/s is about 30 percent higher than the long-term average flow (1150 m^3/s) of the Columbia River at the Keenleyside damsite. Considering the head range limitations of the turbines, it has been assumed that the plant would be shut down when the gross head is less than 7.0 m, corresponding to a reservoir level of about El. 430. The turbine and generator ratings would permit full gate output with the Arrow Lakes Reservoir surcharged from El. 440.1 to 440.7 in years of high runoff.

(v) Generators, Transformers and Switchgear

The three generators would be of the umbrella or semi-umbrella type, having a synchronous speed of 66.67 rpm and a rated capacity of 70 MW (0.90 power factor). No spare transformer would be provided.

Generator circuit breakers would be located in the downstream gallery between the generators and generator transformers.

The generator transformers and 230 kV switchgear would be located on the downstream tailrace deck. This switchgear would connect to 230 kV overhead transmission lines attached to the downstream side of the powerhouse roof.

Station service would be provided from taps off the low voltage buses at 13.8 kV from each unit.

(vi) System Control

The Keenleyside Powerplant would be remotely controlled through the B.C. Hydro microwave system from the Cranbrook Control Centre and from the Burnaby Mountain System Control Centre near Vancouver.

(c) Tailrace and Tailrace Weir

The tailrace channel would have a length of about 150 m and an invert width of 60 to 70 m at El. 414. Although maximum velocities in the channel would be in the order of only 2 m/s, it is expected that some turbulence would occur during operation of the sluiceway and low level ports; therefore, riprap slope protection would be provided.

Based on the preliminary 1983/84 System Plan, the Keenleyside powerplant has been scheduled on the basis of an August 1992 in service date and the Murphy Creek project has been scheduled with a July 1993 first in service date, (the required System Plan in service dates will be subject to annual review). To maintain adequate turbine submergence (necessary to avoid turbine cavitation damage) during this 1 year period, the downstream cofferdam would be left in place with an 80 m portion of its length lowered from El. 426 to about El. 420 to act as a weir. This would allow the tailwater level upstream of the cofferdam to be maintained at levels near the future Murphy reservoir level.

3.4 ADDITIONAL STRUCTURES

(a) Cofferdams

Temporary cofferdams both upstream and downstream of the existing dam would be required for construction of the powerplant.

The upstream cofferdam would be located at the entrance to the powerplant approach channel. It would be a rock and earthfill structure having a length of about 180 m, a height of about 20 m and a fill volume of approximately 90 000 m^3. The crest level has been set at El. 442 m - high enough to permit maximum reservoir operating levels.

The downstream cofferdam is located across the powerplant tailrace channel and would be tied into the existing north bulkhead. It would be a rock and earthfill structure having a length of about 170 m and a maximum height above bedrock of about 30 m. The crest level of El. 426 m is based on the Diversion Design Flood having a return frequency of 1 in 30 years.

(b) Spoil Areas

Seven potential spoil areas comprise two sites above the Robson-Broadwater Highway and five sites on the north shore of the Arrow Lakes Reservoir.

The two spoil areas above the highway are old borrow areas that would be refilled to approximately the original topography. One area on the north shore is also an old borrow area but lies between the north bank of the reservoir and a long, slender island some 80 m offshore (at full reservoir). The remaining four areas would be developed by first constructing retention dykes during the annual low reservoir period. These dykes would be constructed in the dry at a foundation level of about El. 430 m or higher and would be extended upward, as the reservoir refills, to above maximum reservoir level. Granular and rockfill protection would be placed on the face of these dykes to prevent erosion.

The spoil material would be deposited between the dykes and the Robson-Broadwater Highway to levels not exceeding the highway grade.

The space between two spoil areas on the north shore is currently used to some extent as an informal beach area. Disturbance of this area would be avoided.

(c) Access

At the present time public access is provided on the dam crest, connecting the paved highway on the south side of the river with the Robson-Broadwater Highway on the north side of the river.

During construction of the generating facilities, access across the dam would be maintained by rerouting the roadway over the upstream cofferdam. However, because of the narrow crest width and a sharp 90° bend where the cofferdam would abut the north bulkhead, the one-way traffic limitation at the lock would be extended to the west end of the cofferdam. Upon completion of the generating facilities, the roadway would be permanently located across the powerplant intakes.

Because of the extensive excavation required for the approach channel, powerplant and tailrace channel, some 1200 m of the existing Robson-Broadwater Highway would have to be realigned. Advantage would be taken of this realignment to shorten the access routes across the dam and to the powerplant service bay.

SECTION 4.0 - CONSTRUCTION

4.1 CONSTRUCTION SCHEDULE

In accordance with the preliminary 1983/84 B.C. Hydro System Plan, the current engineering schedule for the Keenleyside Powerplant requires completion of Phase 1 of Preliminary Design by 30 April 1983 and completion of Phase 2 of Preliminary Design by 30 April 1984. It is proposed to apply for an Energy Project Certificate (EPC) in early 1984. It has been assumed that B.C. Hydro would be awarded an Energy Project Certificate for Keenleyside by 1 January 1985.

The proposed construction schedule for the 210 MW Keenleyside Powerplant is based on in-service dates specified by the preliminary 1983/84 System Plan.

To achieve the August 1992 in-service date for the first unit it would be necessary to begin construction in late 1986. With award of the first contract (for cofferdams, excavation and construction facilities, primarily) by 1 September 1986 and some 4 1/2 months for tendering and bid evaluation, the tender documents for this critical contract would have to be issued in mid-April 1986.

It would be necessary to issue tender documents for the turbines and generators in March 1986 and award these contracts by September 1986.

With final powerhouse dimensions available in late 1987 it would be possible to issue tender documents for the main civil contract by 1 March 1988 and award the contract by August 1988. Placement of powerhouse concrete would start approximately 7 months later.

The overall construction period, from award of the first contract in September 1986 to the August 1992 in-service date for Unit 1, would be 6 years. Units 2 and 3 are scheduled to be in-service in December 1992 and August 1993, respectively. The in-service dates of all three units are governed to some extent by the annual low reservoir period from January to June (Regime 1).

Construction would begin in November 1986 with the construction camp and offices. In January 1987 work would proceed on the upstream cofferdam. The downstream earth and rockfill cofferdam would start in February 1987 and would be complete by March 1988.

While the cofferdams are being constructed, work would proceed on the main excavation but would be restricted to material above El. 442 until the upstream cofferdam is tested for seepage under full head. Other early work would include relocation of the Robson-Broadwater Highway.

While the cofferdam and excavation work is under way in 1987 and early 1988, the main civil contract for the powerplant would be tendered, with award of the contract in August 1988. Following mobilization, the batch plant and construction cranes would be installed so that placing of concrete could begin in April 1989.

Assembly and installation of the turbine for Unit 1 would begin in October 1990 with Units 2 and 3 following at about 4 to 6-month intervals. Allowing 22 months for turbine and generator installation and testing of each unit, the first unit would be in-service by 1 August 1992 with Units 2 and 3 following in December 1992 and August 1993, respectively.

The upstream cofferdam would be removed during the low reservoir period in early 1992. At about the same time, the downstream cofferdam would be modified for use as a tailrace weir and would remain in place until the Murphy Project is in service in mid-1993.

It should be noted that all of the scheduled dates mentioned in this section and the preceding Section 5.1 are based on a Unit 1 in-service date of August 1992 as stipulated by the preliminary 1983/84 B.C. Hydro System Plan.

4.2 CONSTRUCTION METHODS AND PLANT

The methods and equipment employed for construction of the generating facilities would be of the Contractors' choice. However, for planning purposes, certain assumptions have been made as to the construction methods.

For the cofferdam and excavation contractor, the main activity would involve the placement of some 300 000 m^3 of rock and earthfill in the upstream and downstream cofferdams plus the excavation and disposal of some 1.6 x $10^6 m^3$ (in situ) of silts, sands, gravels and rock. The only suitable spoil areas for the excavated materials appear to be on the north bank of the reservoir approximately 1 to 3 km upstream of the dam.

For the main powerplant contractor, the principal activity would be the batching and placing of some 160 000 m^3 of concrete. The total amount of processed concrete aggregate required would be approximately 190 000 m^3 (340 000 t). Although some of the material may come from required excavation, it is expected that most of the aggregate would be obtained from one of the borrow areas used for the dam construction in the 1960s. This borrow area is located along the Robson-Broadwater Highway, 1.8 km upstream of the dam.

Up to about 60 000 m^3 of glacial till may be required for extension of the impervious blanket through the approach channel for the powerplant. It is expected that this material, along with about 80 000 m^3 of till for the cofferdams, would be obtained from the original Balfour borrow pits northeast of the damsite.

4.3 CONSTRUCTION CAMP

The offices and single labour camp would be located on the north bank, approximately 0.7 km downstream of the dam. This location would provide good access to all work areas and is on property owned by B.C. Hydro. The camp has been designed to accommodate approximately 60 percent of the peak labour force of about 540 with the remainder assumed to reside off-site. The proposed camp would include four two-storey, 80-person bunkhouses, a 350-person dining hall and a recreation hall. Parking would be provided for approximately 200 cars in the immediate vicinity of the camp.

Other facilities would include offices for B.C. Hydro and a materials testing laboratory at the west end of the campsite. Parking would be provided here for approximately 50 cars.

Domestic water would be supplied from two wells drilled in the camp area. For emergency use, two water reservoirs would be located on the higher levels north of the camp and near the highway.

A sewage treatment plant would be constructed at the east (downstream) end of the campsite. Effluent treatment would conform to the requirements of the B.C. Pollution Control Board.

Electric power would be obtained from West Kootenay Power and Light which has a distribution line and 69 kV substation in the immediate area.

SECTION 5.0 - RESERVOIR OPERATION AND FLOWS

5.1 EXISTING OPERATING REGIME

In most years under the existing operating regime for the Arrow Lakes Reservoir, use is made of close to the maximum available live storage. This results in a fairly long period, generally mid-January to mid-June, when the Arrow Lakes Reservoir level is below practical generation levels. If operated under the existing regime (Regime 1), the Keenleyside Powerplant would have to be shut down for about 5 mo/yr. (The head at Murphy would also be significantly reduced during this period to permit the Keenleyside releases.)

5.2 FUTURE OPERATING REGIME

To maximize generation at Keenleyside and Murphy and to mitigate potential environmental impacts caused by reservoir drawdown, several alternative operating regimes for the Columbia River system have been investigated. One of these, termed Regime 2, involves a reduction of about $2.5 \times 10^9 m^3$ in the mean annual drawdown volume of the Arrow Lakes and an increase of about 6.6 m in the mean annual minimum reservoir level.

Under mean water conditions with Regime 2, downtime at Keenleyside due to insufficient head (Arrow Lakes Reservoir levels less than El. 430) would be reduced from about 5 to 2 1/2 months/year and the Murphy Reservoir, in most years, would not have to be drawn down to permit the Keenleyside releases.

For most of the project life Regime 2 is expected to be much more representative of operation than Regime 1. For this reason Regime 2 has been chosen as the basis for project design. When the operating flexibility of the Columbia River Treaty projects improves following expiration of the Treaty, it is expected that the operating regime may be further refined to increase power generation, improve flood control at Trail or reduce the environmental impacts of reservoir drawdown.

5.3 RESERVOIR LEVELS AND DISCHARGES

Compared to existing conditions with no generating facilities, the most significant changes in operation would be the reduced drawdown of the Arrow Lakes Reservoir, a more uniform discharge throughout the year and, most importantly, the diversion of much of the discharge from the sluiceway to the powerplant.

Under existing conditions without the powerplant, most of the water at Keenleyside is discharged through the sluiceway and results in severe gas supersaturation downstream. With the powerplant installed and operated according to Regime 2, approximately 73 percent of the total releases would be made through the powerplant.

5.4 TAILWATER LEVELS

The most significant changes in tailwater levels downstream of Keenleyside would be due to the reservoir created by the Murphy Creek Project which, with a nominal reservoir level of El. 424, would raise the average natural tailwater level at Keenleyside by about 4 m. However, under some flow and system load conditions it would be desirable to match the system load by varying the output at any or all of the Murphy Creek, Brilliant or Keenleyside powerplants. At such

times this could result in daily variations of up to 2 m in the tailwater level near Keenleyside.

To maximize overall generation at Keenleyside, Brilliant and Murphy (El. 424 m), it would be desirable, except as required for occasional load shaping, to regulate the Murphy reservoir to maintain the tailwater level at Keenleyside as near as possible to El. 424 from mid-May to early March of the following year. However, in the spring when the Arrow Lakes Reservoir is drawn down and the available gross head is near the minimum of 7.0 m assumed for turbine operation, it would be possible to reduce the Keenleyside powerplant downtime by drawing the Murphy Creek reservoir down to lower the tailwater level at Keenleyside and thus maintain sufficient head for generation. The benefit from additional energy generated at Keenleyside (some benefit also at Brilliant) would exceed the loss of generation at Murphy Creek for tailwater drawdowns of at least 1 m, and possibly higher. Therefore, pending further study, the Keenleyside turbines have been set at El. 420.0 m based on a minimum tailwater level (for generation) of El. 423 m. This lower setting will also provide some flexibility in the operation of the Murphy Creek Reservoir.

In years of extreme potential for flooding, when the Arrow Lakes will still (even with operating Regime 2) have to be drawn down to levels close to El. 420 m, it would be necessary to lower the Murphy Creek Reservoir also to permit the necessary releases from Keenleyside. These lower Murphy reservoir levels (below El. 423 m) would be required only when the Arrow Lakes Reservoir is below El. 430.0 m, the minimum level for generation at Keenleyside.

5.5 GENERATION

Under Regime 2 average annual generation with the 210 MW capacity and including allowances for reservoir surcharge in high runoff years, would be approximately 880 GW.h (100 average MW).

PART II - PROJECT IMPACTS
SECTION 6.0 - INTRODUCTION

6.1 TERMS OF REFERENCE

The February 1982 terms of reference for Keenleyside detailed environmental studies outline the objectives of the studies. All environmental studies were to assume Murphy El. 424 m (Operating Regimes 1 and 2) and identify any changes or incremental impacts caused by the Keenleyside Powerplant Project. The Keenleyside reports, like this summary report, were intended to be read in conjunction with the Murphy Creek documents, thus avoiding duplication wherever possible.

6.2 STUDY AREA

The study area consisted of all land and water below El. 500 m contour within 10 km upstream of Hugh Keenleyside Dam. The study area for fisheries was to include Lower Arrow Lake and the future Murphy Creek Reservoir; for socio-economics, it was also to include local communities of the Columbia Valley.

6.3 DISCIPLINES

The terms of reference provide guidelines on the level of effort, inventory, planning and assessment requirements for eight study sectors, namely:

Aquatic Resources
Wildlife
Heritage Resources
Socio-economics
Vegetation, Agriculture and Forestry
Recreation
Land Use
Water Use

SECTION 7.0 - STUDY TEAM

7.1 CO-ORDINATION

B.C. Hydro provided general direction for the entire study. This involved: drafting of terms of reference; maintaining study schedules and budgets; ensuring continuous information exchange among participants; monitoring progress; co-ordinating environmental input to project planning; and preparing a final summary report.

7.2 SPECIALIST CONSULTANTS

Specialist consultants were retained by B.C. Hydro to conduct discipline studies and provide planning input in their areas of expertise. Each of the consultants has prepared a discipline oriented report for the Keenleyside Powerplant Project. These reports were used as the basis for this summary and are listed in the Bibliography. The study responsibilities were:

Co-ordination	B.C. Hydro, Environmental and Socio-Economic Services/Monenco Consultants Pacific Ltd.
Aquatic Resources	RL & L Environmental Services Ltd.
Vegetation, Agriculture and Forestry	Talisman Land Resource Consultants
Wildlife	Beak Consultants Limited
Heritage Resources	The Bastion Group/Okanagan College
Socio-Economics	DPA Consulting Ltd.
Recreation	Juan de Fuca Environmental Consultants
Land Use	Urban Systems Ltd.
Water Use	Kerr Wood Leidel Associates Ltd.

SECTION 8.0 - STUDY REQUIREMENTS

The terms of reference direct all participants to utilize the same study objectives, organization, liaison and methodology as described in the Murphy Creek terms of reference.

SECTION 9.0 - VEGETATION

9.1 INTRODUCTION

This section summarizes the project impacts on vegetation and mitigation opportunities within the Keenleyside study area.

9.2 PROJECT IMPACTS

Approximately 4.7 ha of vegetation would be lost due to construction of the powerplant and ancillary developments. Almost all of this area is already highly disturbed, covered mainly with agronomic grass species, knapweed and bracken fern. Vegetation impacts due to powerplant construction, while permanent, are considered minor.

9.3 MITIGATION OPPORTUNITIES

Upon completion of construction, borrow sites and the construction camp site should be revegetated. Potential mixtures include those such as a grass-legume seed mixture of intermediate wheat grass, smooth brome, Canada blue grass, creeping red fescue, climax timothy, alfalfa, white Dutch clover and sweet clover sown at a rate of 30 kg/ha.

SECTION 10.0 - FORESTRY

10.1 INTRODUCTION

This section provides an analysis of the impact on forestry resources of the Keenleyside Powerplant Project, together with possible mitigation opportunities.

10.2 PROJECT IMPACTS

The impact of the proposed powerplant adjacent to the Hugh Keenleyside Dam on the north side of Arrow Lake would be negligible with regard to timber values since this area is already severely disturbed and is not forested. All of the lands in the vicinity of the damsite that are potentially affected by the proposed project have forest capability ratings of Class 3 or Class 4. However, in the absence of the project it is unlikely that these areas would ever be managed for forest production.

10.3 MITIGATION OPPORTUNITIES

Reclamation of borrow pits, spoil areas and the construction camp site in the vicinity of the project to productive forest land is not considered to be a viable option since this land has not been managed as forest land and probably will not be in the foreseeable future.

SECTION 11.0 - WILDLIFE

11.1 INTRODUCTION

This section summarizes the potential impacts of the Keenleyside Powerplant Project on wildlife within the study area.

11.2 PROJECT IMPACTS

The construction of the powerhouse facility and ancillary developments is expected to result only in short-term, minor, negative impacts on wildlife resources. The operation of the Keenleyside Powerplant is not expected to result in any negative impacts to the wildlife of the study area.

11.3 MITIGATION OPPORTUNITIES

Minor impacts to wildlife from renewed disruption of the borrow areas are considered temporary and would be minimized by revegetating the site once construction activities are completed. Impacts on furbearers and birds are considered negligible, and no mitigation measures were recommended.

SECTION 12.0 - AQUATIC RESOURCES

12.1 INTRODUCTION

This section summarizes potential impacts of the project on aquatic resources within the study area and describes possible mitigation opportunities.

12.2 PROJECT IMPACTS

The potential impacts of the Keenleyside Powerplant Project on aquatic resources were evaluated with respect to three major project development phases (i.e. design/pre- construction, construction, operation). Impacts associated with design/pre-construction activities are expected to be of low severity, of short-term duration, and restricted in geographic scope. Construction impacts, although they potentially could be of moderate to high severity, would be of short-term duration and restricted primarily to the immediate vicinity and downstream areas. The main construction- related impacts may include reduced water quality as a result of sediment input or toxic material spills, fish mortality from use of explosives, and increased angling pressure from the localized population buildup.

The operational phase of the project would have both beneficial and adverse impacts on the aquatic resources associated with it. The adverse impact of the development is expected to be a small increase in mortality of fish passing through the turbines relative to the other discharge structures (i.e. sluiceway, low level ports). The significance of this impact and the resulting decrease in recruitment to the downstream fish populations is not known since no data are currently

available relating to the extent, timing, or size distribution of fish displaced through the Keenleyside discharge structures. Based on mortality studies conducted elsewhere, the mortality of fish passing through the turbines at the Keenleyside Project is expected to be low (i.e. possibly 5 to 10 percent), and therefore would likely result in a small decrease in recruitment of fish to the downstream fishery.

The addition of a generating capacity at the Hugh Keenleysdie Dam is not expected to significantly affect the downstream transport of Mysis relicta and other zooplankton from the Arrow Lake Reservoir to the Columbia River. This conclusion is based on the fact that the crest elevation of the intake channel to the power facility (El. 423 m) is not substantially different from the crest elevation of the sluiceway (El. 424.9 m). However, if current flow patterns in front of the powerplant intake channel differ significantly from the current patterns in front of the sluiceway, small changes in the number of organisms which become entrained during powerplant operations may occur.

The passage of approximately 55 percent of the mean annual flow through the turbines under Operating Regime 1 (73 percent under Operating Regime 2) is expected to have a beneficial impact on downstream fish populations by reducing total dissolved gas saturations. Since it is not presently known to what extent the high total dissolved gas levels in the Columbia River cause mortality or affect the growth rates of resident fish, it is not possible to quantify the likely benefits of the expected reduction of saturation levels as a result of adding generating capacity at the Hugh Keenleyside Dam.

No significant impacts on the limnology or fish population in Lower Arrow Lake attributable to powerplant operation are expected.

12.3 MITIGATION OPPORTUNITIES

Selected mitigation opportunities which could be implemented during the construction phase of the project development include:

1. Adequate construction procedures to minimize sediment input to the Lower Arrow Lake and Columbia River such as riprapping unstable slopes, location of borrow areas away from active stream channels, diversion of runoff or effluent to settling ponds.

2. Preparation of contingencies plans in the event of accidental spills.

3. Construction of berms around all fuel storage or chemical storage areas.

4. Minimization of the use of underwater explosives.

5. Monitor angling pressure exerted by project staff so that appropriate management procedures (e.g. area closures, reduction of catch limits) may be implemented as required.

Mitigation opportunities suggested for the operational phase of the development include:

1. Whenever large volumes of water are discharged the low level ports should be used to minimize the development of gas supersaturation downstream of the Hugh Keenleyside Dam.

2. Maintenance of highest possible tailwater levels and setting the Kaplan turbine blades for maximum efficiency during significant downstream fish passages to minimize fish mortality within the powerplant.

3. Placement of a floating screen deflector system across the top of the powerplant approach channel to divert fish towards the low level ports or sluiceways (although this technique may not be cost effective for this project).

SECTION 13.0 - WATER USE

13.1 INTRODUCTION

The potential impact on water systems during the project construction period is reviewed in this section and possible mitigation measures to reduce these impacts suggested.

13.2 PROJECT IMPACTS

With completion of the Keenleyside Powerplant Project, reservoir levels and discharge conditions for the Lower Arrow Lake and Columbia River system would be representative of that prior to construction under Operating Regime 1. With Operating Regime 2 the drawdown of the Arrow Lakes Reservoir would be reduced and discharge throughout the year would be more uniform. The focus therefore is on impact during construction. Given that the powerplant and related facilities are proposed to be constructed under fully controllable conditions "in the dry" behind cofferdams, the impact on water use as a result of the Keenleyside Powerplant Project is predicted to be negligible. Implementation of the Keenleyside Powerplant Project, either in conjunction with, or after the Murphy Creek Project, is not expected to result in any additional impacts to those previously identified in the Murphy Creek Project water use studies.

Providing standard engineering protective measures are implemented as part of a sediment containment plan during development of a proposed borrow area and disposal of excavated spoil materials, negligible effects are foreseen to present water quality (turbidity) or water use.

13.3 MITIGATION OPPORTUNITIES

In view of the conclusions that project impacts to water use would be insignificant, no mitigation measures were suggested.

It was recommended that basic control measures for a sediment containment plan for borrow pit and spoil areas include:

1. Vegetated buffer zones down slope of work areas.

2. Small depressions or dykes to intercept sediment near the point of origin.

3. Settling basins near the perimeter of the site to capture the runoff and additional sediment.

SECTION 14.0 - LAND USE

14.1 INTRODUCTION

This section presents an overview on those aspects of the study area environment pertaining to the use of land for human settlement including residential, recreational, institutional and commercial uses relative to land use inventory, land use planning and the adequacy of present land use planning policies.

14.2 PROJECT IMPACTS

The impacts of the Keenleyside Powerplant Project from a land use perspective are temporary or short-term in duration. None of the permanent project components would have a significant impact on existing, planned or proposed land uses. Of the temporary or short-term project components, only two would have any significant impact of the study area - temporary employee housing, as well as increased auto and heavy truck traffic volumes and possible associated safety hazards, particularly on Robson-Broadwater Highway. It is estimated that there would be an incremental demand for approximately 30 housing units (preliminary estimate) by the Keenleyside temporary employees. The second impact, increased auto and truck traffic volumes, would result in increased traffic volumes along the Robson-Broadwater Highway and increased ferry patronage. The increased traffic volumes may result in conflicts between residents along the highway who would have to cross the project-related traffic flow during rush hours to gain access to their residences. The potential for increased safety hazards for bicyclists and pedestrians also exists. Increased ferry patronage may result in waits on either end of the crossing.

14.3 MITIGATION OPPORTUNITIES

In order to mitigate any adverse impacts associated with the project, a number of recommendations were made. These are in addition to those made in the Murphy Creek Hydroelectric Development Land Use Study for the El. 424 m reservoir level. The additional recommendations are:

1. Provide for appropriate reclamation of all borrow pits.

2. Schedule construction activity so that construction on the Robson-Broadwater Highway does not coincide with construction of the dam access road.

3. Provide a haul road so that heavy truck traffic from the borrow pit along Lower Arrow Lake will not restrict access to properties and public facilities along the reservoir.

4. Design the construction camp to minimize potential conflicts with surrounding land uses. Provision of a buffer surrounding the camp is one possible solution.

5. Instigate programmes and strategies designed to reduce traffic volumes along Robson-Broadwater Highway. Suggestions include: car pooling, staggered working hours, parking lots at south end of dam, and locating camp at southern end of dam.

6. Undertake a more detailed transportation analysis, taking into consideration the existing condition and function of Robson-Broadwater Highway, existing traffic volumes, and projected increases in traffic-type and volume of vehicles. The analysis would also examine the impact of increased traffic volumes on the Robson-Castlegar ferry service, and necessary mitigation measures.

7. Increase the required new residential developments recommended for the Murphy Creek Project to reflect the incremental demand resulting from the Keenleyside Powerplant Project. (This recommendation assumes a zero percent vacancy rate in the housing market.)

SECTION 15.0 - AGRICULTURE

15.1 INTRODUCTION

This section discusses the impacts on agricultural resources in the study area.

15.2 PROJECT IMPACTS

There does not appear to be a potential for impact on agriculture by the construction activities as the lands designated for agriculture are located considerably to the west of the proposed construction site.

The proposed construction camp location is on the former dam construction campsite. As the soils already have been disturbed by former construction activities this appears to be the most suitable location for the new camp. This area is not within the ALR and has no capability for arable agriculture in its present state and little scope for agricultural reclamation.

15.3 MITIGATION OPPORTUNITIES

The proposed borrow sites appear to have very little if any potential for agricultural use. On this basis, reclamation for the benefit of agriculture is not seen as a requirement.

SECTION 16.0 - RECREATION

16.1 INTRODUCTION

Section 16.0 provides an overview of project impacts on existing and planned recreational/tourism facilities within the study area.

16.2 PROJECT IMPACTS

Overall, the potential impact of the Keenleyside Powerplant Project upon outdoor recreation is expected to be slight. There appear to be few slight to moderate negative impacts in the short term with long-term impacts upon recreation assessed as being positive. Table 16-1 summarizes the general types and degree of impact potential for outdoor recreation.

Disruption of traffic across the dam and relocation of the Robson-Broadwater Highway would have a slight impact upon tourist and recreation traffic to Lower Arrow Lake. The most significant potential for impact upon outdoor recreation would be any short-term disruption to fishing downstream of Hugh Keenleyside Dam. Some impact is also expected as the result of the construction labour force placing added demands upon existing recreation facilities and opportunities. The existing Balfour borrow pit poses an existing negative impact upon visual quality. Borrow requirements for the proposed project are expected to be relatively low with the consequence of a slight addition to the existing negative visual feature.

Under operating Regime 1, the timing and amount of drawdown of Arrow Lakes Reservoir would change little with operation of the proposed

powerplant. As a consequence, no impact is anticipated upon recreational opportunities associated with the reservoir such as swimming, fishing and boating. However, adoption of operating Regime 2 (which features less seasonal drawdown in Arrow Lakes Reservoir) would enhance recreational opportunities along the reservoir shoreline.

16.3 MITIGATION OPPORTUNITIES

1. Reclamation of the Balfour borrow pit following construction would reduce the negative visual impact.

2. Implementation of the fisheries mitigation opportunities (see Section 12.3) would minimize the impacts on fishing downstream of the dam.

TABLE 16-1

SUMMARY OF PROJECT IMPACTS ON RECREATION

Nature of Impact	Short Term (Construction Period) Impact Potential	Long Term (Operating) Impact Potential	
		Regime 1	Regime 2
Lower Arrow Lake waterbased recreation use and potential	none	none	positive
Pleasure boat use of Hugh Keenleyside Lock	none	none	none
Upland Recreation	slight	none	none
Columbia River sport fishing	moderate	slightly positive	slightly positive
Demand upon recreation resources and facilities from powerplant construction workforce	moderate	none	none
Borrow pit visual factor	slight	slight	slight

SECTION 17.0 - SOCIO-ECONOMICS

17.1 INTRODUCTION

This section examines socio-economic conditions in the study region (Kootenay Boundary Regional District plus Central Kootenay Regional District) and the study area (School District No. 9 - Castlegar, and School District No. 11 - Trail). Assessment of potential socio-economic impacts of the Keenleyside Powerplant and Murphy Creek projects including transmission employment was combined as the impacts are, in many cases, cumulative. However, where possible public concerns and issues related specifically to Keenleyside were identifed and potential mitigation measures suggested.

17.2 PROJECT IMPACTS

Based on tentative System Plan requirements construction of the Keenleyside Powerplant Project would begin in late 1986 and be completed in August 1993. Murphy Creek Project construction would go from the spring of 1988 to the fall of 1994. If the two projects proceed sequentially, workers would have the opportunity to move from one project to another. In total, the Keenleyside-Murphy Project would create 5500 person-years of employment. Local employment on the project would be high (66 percent) due to projected high unemployment rates in the study area and among local union members now working outside the area. If Keenleyside proceeds alone, the local share of employment would be even higher, (87 percent) reflecting its smaller construction labour force, but person-years of employment would be less.

The in-migrant labour force would have a small population impact on the Castlegar/Trail area. While most (75 percent) of the supervisory and

owner's staff would bring their families and take up residence, other occupational categories would be more likely to reside in construction camps because, typically, they would only be needed for a year or less. During the peak year of construction, 1991, there would be an additional 235 permanent residents in the Castlegar/Trail area and an average of 557 in the construction camps. If Keenleyside proceeds alone, the average during the peak year, 1991, would be 79 permanent residents and 65 in the construction camp.

Overall, the project would have a positive, but very small impact on the population of the study area. It would result in a deceleration in the rate of decline projected for the 1986 to 1994 period. Particularly noteworthy is the very slight impact of the Keenleyside Powerplant Project if it proceeds on its own. Corresponding to the project's small population impact, the effects on municipal infrastructure and community services would also be small and could even be favourable to the extent that the project-induced population would allow these services to operate at closer to full capacity over the 1986 to 1994 period.

Expenditures on the Keenleyside-Murphy Project within the Castlegar/ Trail area would initiate a cycle of spending resulting in additional jobs and incomes for local residents and businesses, in-migrant workers, and individuals and firms outside the study area. When the direct, supplier-related and respending effects are combined, the project would add more than 1500 jobs to the study area economy in the peak construction year, 1991/92. This represents a 6 percent increase compared to the without-the-project projections. The unemployment rate in the peak construction years (1989 to 1993) would decrease from an average of 11 percent to an average of 7 percent as a consequence of the project. Over the total construction period (1986 to 1994), almost $141 million ($ 1980) would be added to the personal incomes of the permanent residents of the Castlegar/Trail area. In the peak construction year, the relative impact on total personal income would also be about 7 percent. The relative impact on personal income per capita would be

somewhat lower, but still highly significant. Throughout the 1989 to 1993 period, per capita income in the study area would be from 4 to 6 percent closer to the provincial average as a consequence of the project. In general, the project would have a favourable effect on the study area's economy and would help offset the effects of the employment reduction at Cominco. The absolute impact of the Keenleyside Powerplant Project would be about 35 percent of the impacts of the two projects combined.

In the operating phase, the Keenleyside-Murphy Project is expected to employ a total of 24 employees at the two sites. Additional employment of 30 to 40 people for a 6-week period would result from annual maintenance. Respending of income would generate up to six additional jobs in the service sector. The annual increment to the personal income of the study area's permanent residents would be approximately $900,000. This represents less than 0.2 percent of aggregate personal income projected for the area.

The effects on local government finance would be quite subtle and as such, have not been precisely quantified. In any event, the impacts would be small and are expected to be distributed among a number of municipalities. Therefore, a detailed analysis appears unnecessary.

The incremental social impacts of the Keenleyside Powerplant Project are expected to be limited and mostly positive. This situation reflects the following factors:

1. The project would create much needed jobs and income for local residents.

2. The relatively small number of in-migrant workers and their dependents means that local services would not be overburdened.

3. The relatively small number of construction camp residents and the fact that many would likely be middle-age people suggests that social disruption would be limited.

4. There are no long-term environmental impacts from the Keenleyside Powerplant Project.

5. Local attitudes to the Keenleyside Powerplant Project are positive.

There is strong local support for the Keenleyside Powerplant Project and people want it to proceed as quickly as possible so the community can obtain the employment and income benefits. There is more ambivalence toward the Keenleyside-Murphy Project because of the potential environmental impacts of Murphy Creek and the relocation of residents who live along the river bank.

The main concerns of local residents regarding the Keenleyside Powerplant Project are traffic congestion on Columbia Street and increased strain on recreation facilities. The only other incremental social impact foreseen would be the disturbance from noise, dust, and vibration to residents who live near the construction site.

Overall, the socio-economic impacts of the Keenleyside Powerplant Project combined with Murphy Creek El. 424 m Project are clearly positive. No serious negative socio-economic effects have been identified. The socio-economic impacts would be equally favourable if Keenleyside were to proceed on its own.

17.3 MITIGATION OPPORTUNITIES

The mitigation and compensation measures described in the Murphy Creek report cover most of the socio-economic issues presented by the Keenleyside Powerplant Project. Since this project would be centred in

Castlegar, it is most important that B.C. Hydro initiate a joint planning process with the City of Castlegar to resolve local issues and concerns. Problem resolution is best accomplished by informal negotiations and discussions among the parties involved. The formal procedure of the B.C. Utilities Commission is an appropriate forum for those issues on which agreement cannot be reached.

SECTION 18.0 - HERITAGE RESOURCES

18.1 INTRODUCTION

This section provides a description of potential impacts on heritage resources within the study area.

18.2 PROJECT IMPACTS

Five potential heritage resource areas were intensively investigated in the proposed project area. No heritage resources were found and heritage sites identified before construction of the Hugh Keenleyside Dam could not be relocated. Presumably, construction activity in this area has obliterated these sites.

18.3 MITIGATION OPPORTUNITIES

Conservation, compensation or mitigation procedures are not recommended as heritage resources would not be endangered by the project. A monitoring program is recommended during construction in areas of major land disturbance.

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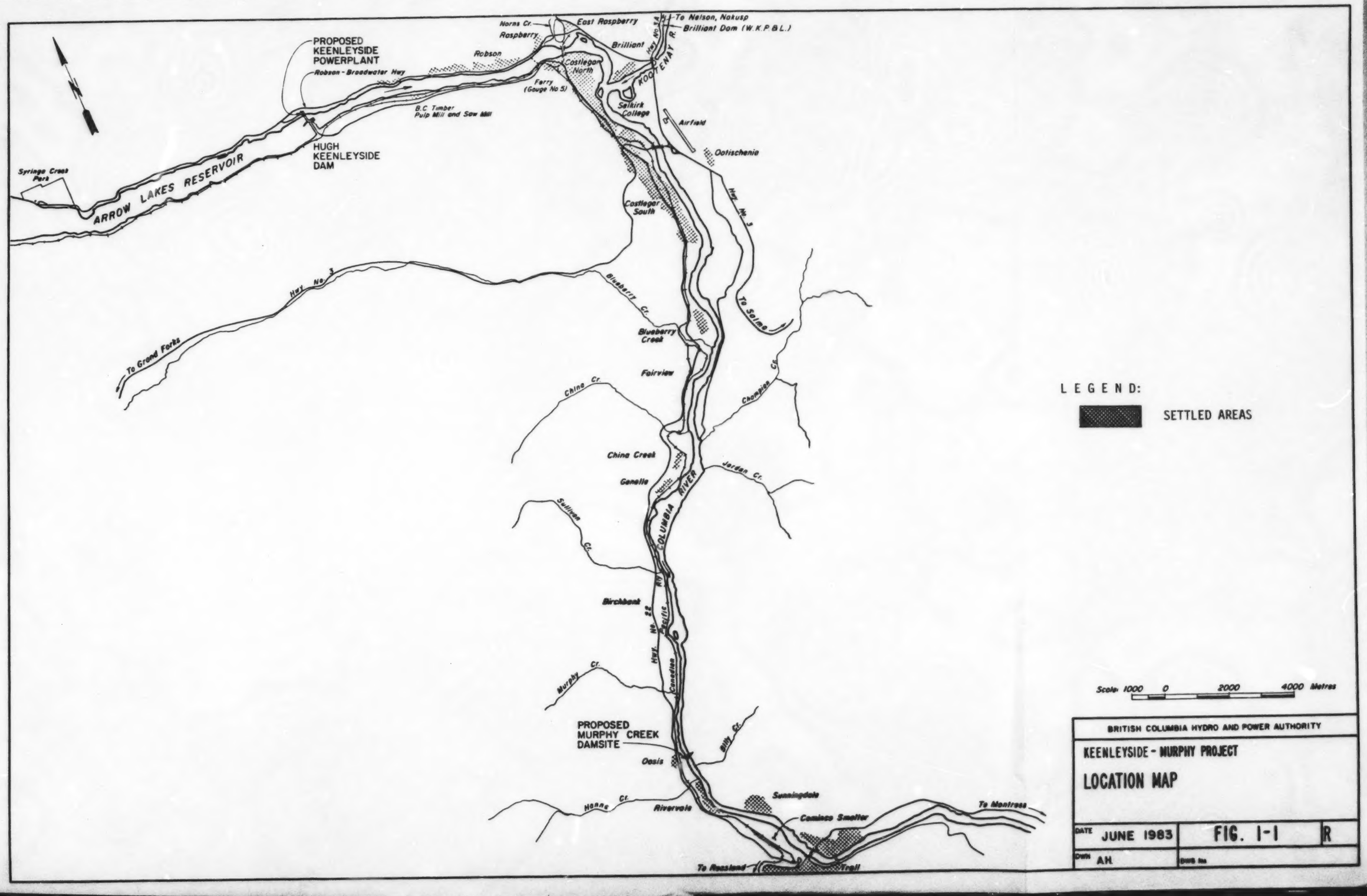
PROPOSED
KEENLEYSIDE
POWERPLANT
Robson - Broadwater Hwy
HUGH
KEENLEYSIDE
DAM
ARROW LAKES RESERVOIR
Syringe Creek
Park
B.C. Timber
Pulp Mill and Saw Mill
Norns Cr.
Raspberry
East Raspberry
Robson
Brilliant
Castlegar
North
Ferry
(Gauge No 5)
Hwy No 3A
To Nelson, Nakusp
Brilliant Dam (W.K.P.&L.)
KOOTENAY R.
Selkirk
College
Airfield
Ootischenie
Castlegar
South
Hwy No 3
To Salmo
Blueberry Cr.
Blueberry
Creek
Fairview
Champion Cr.
Hwy No 3
To Grand Forks
China Cr.
China Creek
Ganolla
Jordan Cr.
COLUMBIA RIVER
Sullivan
Cr.
Hwy No 22
Beaver
Canadian
Birchbank
Murphy Cr.
PROPOSED
MURPHY CREEK
DAMSITE
Oasis
Billy Cr.
Hanna Cr.
Rivervale
Sunningdale
Cominco Smelter
To Montrose
To Rossland
Trail
LEGEND:
SETTLED AREAS
Scale 1000 0 2000 4000 Metres
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
KEENLEYSIDE - MURPHY PROJECT
LOCATION MAP
DATE JUNE 1983
FIG. 1-1
R
DWN AH
DWG No.